

AMENDMENTS TO THE CLAIMS:

This listing of claims will replace all prior versions, and listings, of claims in the application:

Listing of Claims:

1. (currently amended) An apparatus for online signature verification using ~~analyzing~~ a reference signature database (DB) ~~of a specific user~~, the apparatus comprising:
 - a signature data input unit for digitalizing a locus of a user's input signature and reading the digitized locus as a signature sequence of sample points sampled at regular time intervals;
 - a first pattern transform unit for performing a speed equalization on the signature sequence read by the signature data input unit and generating a first transformed pattern sequence, wherein ~~said speed equalization is based on the assumption that linear velocities at the sample points on the locus are equal to a constant value~~;
 - a second pattern transform unit for performing a velocity transformation on the signature sequence read by the signature data input unit and generating a second transformed pattern sequence;
 - a feature extraction unit for extracting a characteristics vector ~~three feature vectors~~ from the signature sequence ~~read by the signature data input unit~~, the first transformed pattern sequence ~~transformed by the first pattern transform unit~~ and the second transformed pattern sequence ~~transformed by the second pattern transform unit, respectively, to thereby generate the three feature vectors having different information~~;
 - a difference vector estimation unit for generating a difference vector between [[the]] a feature vector of the specific user's reference signature read from the reference signature DB and the characteristics ~~feature~~ vector extracted by the feature extraction unit; and

a determination unit for determining whether [[an]] the input signature and the reference signature are signed by the same a single person or not, based on the difference vector generated from the difference vector estimation unit.

2. **(currently amended)** The apparatus of claim 1, wherein ~~the first pattern transform unit transforms the signature sequence read by the signature data input unit and generates the first transformed pattern sequence, the speed equalization is transform being performed by using [[a]] the following equation:~~

(Equation)

$$\begin{aligned} s_i &= p_i & i &= 1, 2 \\ s_i &= s_{i-1} + (p_i - p_{i-1}) & i &= N-1, N \\ s_i &= s_{i-1} + v\Delta t \cdot \Theta & \text{otherwise} \end{aligned}$$

wherein p_i , s_i , v , Δt , and Θ represent a point on an input signature pattern locus, s_i , is an element of a transformed two dimensional vector list, a velocity, a time interval between sample points, and a unit vector in the direction of θ , i.e., in the locus at the point p_i , respectively

p_i represents the i^{th} sample point on the signature sequence of the digitized locus,

s_i represents the corresponding i^{th} element of the first transformed pattern sequence,

v represents the constant velocity,

Δt represents the sampling time interval between the sample points on the signature sequence, and

Θ represents a unit vector in the direction θ of the digitized locus at the sample point p_i .

3. **(currently amended)** The apparatus of claim 1, wherein ~~the second pattern transform unit transforms the signature sequence read by the signature data input unit and generates the second transformed pattern sequence, the velocity transformation is [[being]] performed by using [[a]] the following equation:~~

(Equation)

$$\begin{aligned} v_i &= v_3 & i &= 1, 2 \\ v_i &= v_{N-2} & i &= N-1, N \\ v_i &= (v_{xi}, v_{yi}) & \text{otherwise} \end{aligned}$$

wherein [[the]]

~~v_i is the ith element of the second transformed pattern sequence an element of the transformed two dimensional vector list, and~~

~~v_{xi} and v_{yi} are first horizontal and vertical derivatives at the corresponding sample point p_i on the digitized input signature pattern locus.~~

4. **(currently amended)** The apparatus of claim 1, wherein the speed equalization is a technique for recomposing a signature pattern based on an inverse proportional relation between a signature speed and a length of the pattern, and the velocity transformation is a technique for transforming a spatial pattern into a velocity domain.

5. **(currently amended)** An ~~method for~~ online signature verification ~~method using~~ analyzing a reference signature DB ~~of a specific user~~, the method comprising the steps of:

(a) digitalizing a locus of a user's ~~input~~ signature and reading the digitized locus as a ~~signature~~ sequence of ~~sample~~ points sampled at regular time intervals;

(b) performing a speed equalization on the signature sequence read in the step (a) to generate a first transformed pattern sequence, ~~wherein said speed equalization is based on the assumption that linear velocities at the sample points on the locus are equal to a constant value;~~

(c) performing a velocity transformation on the signature sequence read in the step (a) to generate a second transformed pattern sequence;

(d) extracting ~~a characteristics vector~~ ~~three characteristics vectors~~ from the signature sequence read in the step (a), the first ~~transformed~~ pattern sequence ~~generated~~ ~~transformed~~ in the step (b) and the second ~~transformed~~ pattern sequence ~~generated~~ ~~transformed~~ in the step (c), respectively, to thereby generate ~~three characteristics vectors having different information;~~

(e) generating a difference vector between a feature the characteristics vector of the specific user's reference signature read from the reference signature DB and the characteristics vector extracted in the step (d); and

(f) determining whether [[an]] the input signature and the reference signature are signed by the same a single person or not, based on the difference vector generated in the step (e).

6. (new) The method of claim 5, wherein the speed equalization is performed by using the following equation:

$$\begin{aligned} s_i &= p_i & i &= 1, 2 \\ s_i &= s_{i-1} + (p_i - p_{i-1}) & i &= N-1, N \\ s_i &= s_{i-1} + v\Delta t \bullet \Theta & \text{otherwise} \end{aligned}$$

wherein

p_i represents the i^{th} sample point on the signature sequence of the digitized locus,

s_i represents the corresponding i^{th} element of the first transformed pattern sequence,

v represents the constant velocity,

Δt represents the sampling time interval between the sample points on the signature sequence, and

Θ represents a unit vector in the direction θ of the digitized locus at the sample point p_i .

7. (new) The method of claim 5, wherein the velocity transformation is performed by using the following equation:

$$\begin{aligned} v_i &= v_3 & i &= 1, 2 \\ v_i &= v_{N-2} & i &= N-1, N \\ v_i &= (v_{xi}, v_{yi}) & \text{otherwise} \end{aligned}$$

wherein

v_i is the i^{th} element of the second transformed pattern sequence , and

v_{xi} and v_{yi} are first horizontal and vertical derivatives at the corresponding sample point p_i

on the digitized locus.

8. (new) The method of claim 5, wherein the speed equalization is a technique for recomposing a signature pattern based on an inverse proportional relation between a signature speed and a length of the pattern, and the velocity transformation is a technique for transforming a spatial pattern into a velocity domain.

9. (new) The method of claim 6, wherein the direction θ of the digitized locus at the sample point p_i is determined by the following equation:

$$\theta = \arctan(v_{yi}/v_{xi})$$

wherein

v_{xi} and v_{yi} are first horizontal and vertical derivatives at the sample point p_i .

10. (new) The method of claim 9, wherein the velocity transformation is performed by using the following equation:

$$\begin{array}{ll} v_i = v_3 & i = 1, 2 \\ v_i = v_{N-2} & i = N-1, N \\ v_i = (v_{xi}, v_{yi}) & \text{otherwise} \end{array}$$

wherein

v_i is the i^{th} element of the second transformed pattern sequence.

11. (new) The method of claim 10, wherein the first horizontal and vertical derivatives at the sample point p_i are determined by the following equations:

$$\begin{aligned} v_{xi} &= (-p_{i+2}(x) + 8p_{i+1}(x) - 8p_{i-1}(x) + p_{i-2}(x))/12 \\ v_{yi} &= (-p_{i+2}(y) + 8p_{i+1}(y) - 8p_{i-1}(y) + p_{i-2}(y))/12. \end{aligned}$$

12. (new) The method of claim 5, wherein the sample points are distributed according

to a radial histogram which comprises bins successively arranged around the origin of a Cartesian coordinate system, and wherein the distribution is based on locations where the locus passes.

13. (new) The apparatus of claim 2, wherein the direction θ of the digitized locus at the sample point p_i is determined by the following equation:

$$\theta = \arctan(v_{yi}/v_{xi})$$

wherein

v_{xi} and v_{yi} are first horizontal and vertical derivatives at the sample point p_i .

14. (new) The apparatus of claim 13, wherein the velocity transformation is performed by using the following equation:

$$\begin{aligned} v_i &= v_3 & i &= 1, 2 \\ v_i &= v_{N-2} & i &= N-1, N \\ v_i &= (v_{xi}, v_{yi}) & \text{otherwise} \end{aligned}$$

wherein

v_i is the i^{th} element of the second transformed pattern sequence.

15. (new) The apparatus of claim 14, wherein the first horizontal and vertical derivatives at the sample point p_i are determined by the following equations:

$$v_{xi} = (-p_{i+2}(x) + 8p_{i+1}(x) - 8p_{i-1}(x) + p_{i-2}(x))/12$$

$$v_{yi} = (-p_{i+2}(y) + 8p_{i+1}(y) - 8p_{i-1}(y) + p_{i-2}(y))/12.$$

16. (new) The apparatus of claim 1, wherein the sample points are distributed according to a radial histogram which comprises bins successively arranged around the origin of a Cartesian coordinate system, and wherein the distribution is based on locations where the locus passes.